

Recommendations & Instructions for Operating

BABCOCK & WILCOX

C.T.M. Boiler Plant



BABCOCK & WILCOX LIMITED

Babcock House, Farringdon Street
LONDON, E.C.4

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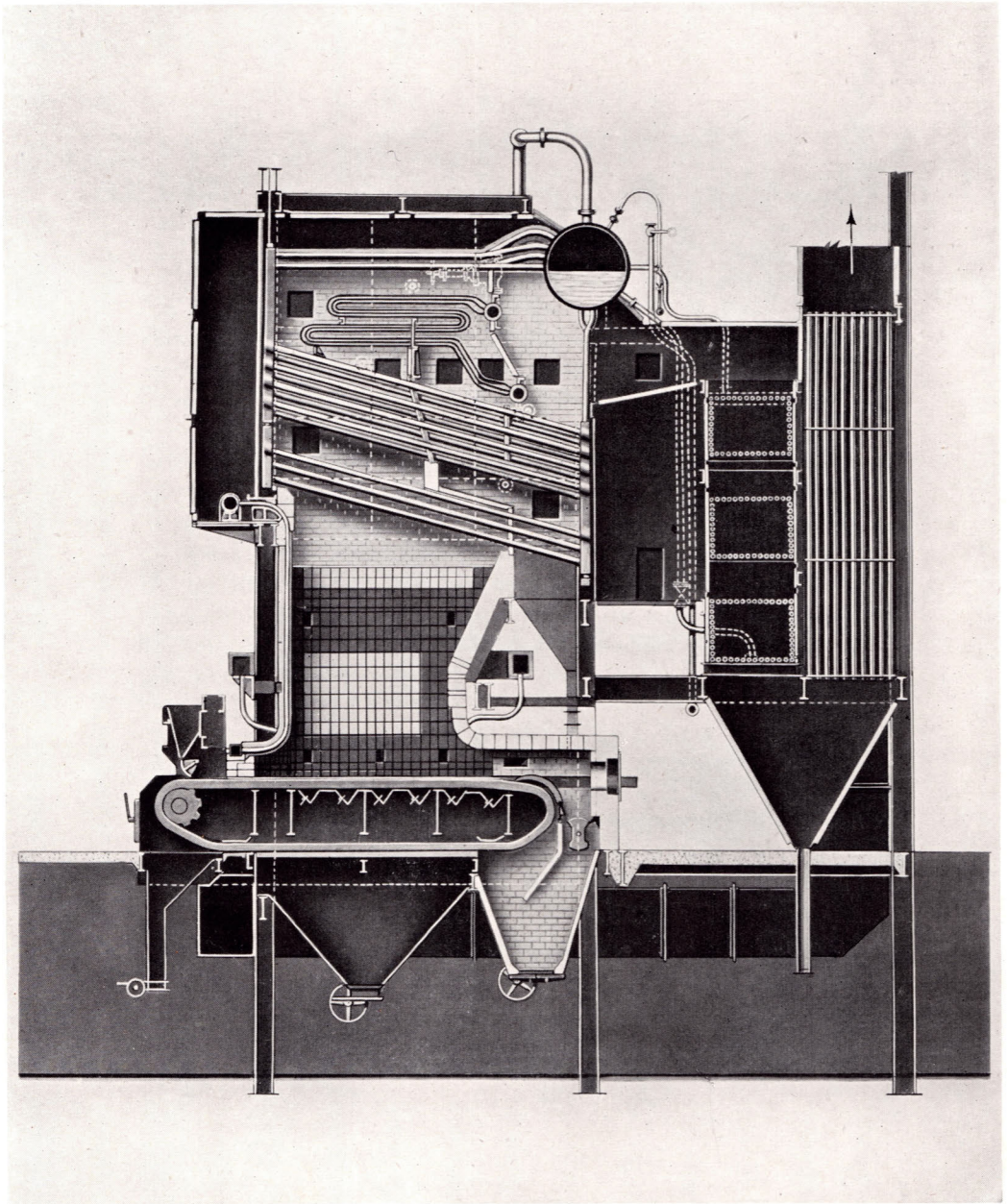
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These Recommendations and Instructions have been formulated as a guide to the starting up and operation of C.T.M. Boiler Plant of Babcock & Wilcox manufacture, and presume a knowledge of steam engineering practice. They should not be regarded as rigid and inflexible, for it should be fully appreciated that conditions and circumstances encountered on individual plants may necessitate minor modifications. However, if important changes are made, the Service Department should be informed. Where progress in design places a paragraph out of alignment with the requirements of a new plant, the paragraph should be interpreted in the light of current circumstances and the advice of the Service Department or nearest Branch Office obtained on the matter. Where other makers' equipment is supplied by Babcock & Wilcox Ltd. as main contractors, the makers' own instructions should be adhered to.

BABCOCK & WILCOX LTD.,
Service Department,
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Typical Stoker-fired C.T.M. Boiler Unit

Recommendations and Instructions

for

Operating C.T.M. Boiler Plant

INSPECTION OF NEW BOILER PLANT

(1) When the erection of a new boiler unit is approaching completion the engineer responsible for putting it into service should make a comprehensive inspection of the unit and its equipment to satisfy himself that all is in operational order. The assurance of the senior erector should be obtained regarding the condition of any parts which cannot be examined without troublesome dismantling and consequent delay. At this stage all operators should make themselves acquainted with the unit and its equipment so that they will be able to act promptly if an emergency should arise.

(2) Before the pressure parts are closed up to be filled with water for the hydraulic test a search should be made by the erector for foreign matter, such as wood, sacking, tools, bolts and small pieces of metal. A tube brush or ball should be passed through boiler and furnace wall bent tubes to make sure they are clear. Straight boiler tubes should be sighted with a lamp or brushed through if necessary. Superheater tubes and economiser tubes should be cleared by blowing through with a jet of water or compressed air. After removal of dirt, all parts should be washed through with a hose. Blowdown valves and furnace wall drain valves should receive special care to prevent fouling or damage by foreign matter, and should be thoroughly washed through and operated before the boiler is filled with water.

(3) After the hydraulic test, when the water pressure has been reduced to 50 p.s.i., the handhole cap joints should be retightened by one man to ensure that no joint is overlooked, taking care to work upwards from the bottom row to avoid disturbing any loose caps by standing upon the projecting cap nuts. The spanners provided are designed to permit the nuts to be tightened sufficiently without straining the threads, and pipe extensions giving extra leverage should not be permitted. The retightening of cap joints is an operation requiring care and skilled attention.

(4) Make sure that the direction of rotation of all motors is correct, and that all bearings of fans, pumps etc. (except ball or roller bearings which are grease packed) have been washed out with petrol or paraffin and properly lubricated, and that oil rings run freely. The instructions concerning the various parts of the auxiliary equipment should be followed and all equipment should receive attention to bring it to a condition of readiness for service. Pulverising mills should not be run without coal for longer than necessary, but all other power-driven plant should be operated, where possible, for several hours with constant supervision.

(5) Examine gauges and boiler mountings, operate valves and see that they are correctly installed and free to work. Examine the steam drum internally, see that all tubes are clear and make sure that the interior orifices of water gauges and other drum mountings are clear. Internal drum fittings should not be fitted until after the unit is boiled out.

(6) Confirm that boiler header and superheater header sling rods are in tension and that the weight is distributed over all points of suspension. See that the front and rear nipple seals (including the superheater tube seal) are gas tight, and the boiler gas pass baffles are satisfactory. See that the spaces between the boiler headers are well packed with asbestos rope and make sure that the lower wing headers can expand downwards without fouling side wall brickwork.

(7) See that the movable seals beneath the front and rear headers are correctly fitted, and that the clearances under the headers for downward expansion are as indicated on the detail drawings.

(8) It is important to check all expansion clearances to make sure that they are not less than shown on the drawings, as insufficient clearance may cause trouble. Any brickwork or other obstruction must be cut away to restore clearances to drawing dimensions. It should not be assumed that clearances allowed during erection exist after the hydraulic test, as the pressure parts may have changed position slightly.

(9) The largest expansion movement occurs at positions remote from the anchored points, such as at the mud drum and lower parts of the front and rear headers, at the furnace wall headers and the lower superheater header. Furnace side walls on stoker fired units are anchored at the bottom and expand upwards; on pulverised fuel fired units they are usually anchored at mid position and expand upwards at the top and downwards at the bottom. Blowdown pipes, superheater drains and furnace wall drains must be free to move downwards. Closing plates in boiler side casings through which these pipes pass must have the necessary freedom and clearance.

(10) The clearances under boiler headers and furnace wall headers, and between the lowest row of boiler tubes and the tops of the front and rear furnace walls are likely to fill with broken brick during the final stages of construction. After checking these clearances, inspect them again when construction is complete and the unit has been cleaned down, to make sure they are clear. Examine boiler side wall brickwork and furnace wall brickwork to see that it does not restrict expansion of the pressure parts at any point.

(11) Operate all sootblowers after reading the soot blower instructions, see that they are correctly fitted and free to operate, and that angles of sweep and settings agree accurately with the drawings. See that retractable furnace blowers travel freely and that there is no possibility of the steam jets impinging on the furnace wall through which the nozzles pass.

(12) See that no timber or rubbish is left inside the boiler, economiser, air heater, or in the gas or air ducts, hoppers, grit collectors, fans, etc., and that the

casings of these parts are gastight. Air leakage can be responsible for serious loss of efficiency. See that all temporary spacing bolts are removed from duct expansion joints to allow the joints freedom. Check fan impeller clearances.

(13) Operate dampers to see that they move freely and have sufficient clearance to maintain free movement at the working temperature. Examine dampers and control gears in the open and closed positions, see that dampers close properly, and check the indicators to make sure the damper positions are accurately indicated.

(14) Examine the arrangements for removing ash from the furnace, see that ash hoppers are clear and that ash doors open and close satisfactorily.

(15) Confirm that main steam and feed pipe lines are complete and have freedom to expand, and that rollers in pipe line supports are free to roll. Inspect new auxiliary steam equipment and operate new valves, except any under pressure as isolators. See that valve extension spindles are complete and lubricators in order. See that safety valve escape pipes are supported and led to suitable points of discharge to avoid injury to personnel, and that safety valves are effectively drained. See that all drain and blowdown pipes are adequately supported and either connected to the blowdown tank or temporarily led to suitable points of discharge. Try blowdown and drain valve keys to make sure they cannot be removed whilst the valves are open.

(16) Charge the feed pipe lines with water, and feed the boiler unit through the economiser until there is 6 in. depth of water in the bottom of the drum. Leave the drum open ready for adding chemicals for boiling out. See that gauge glasses are in order and properly illuminated.

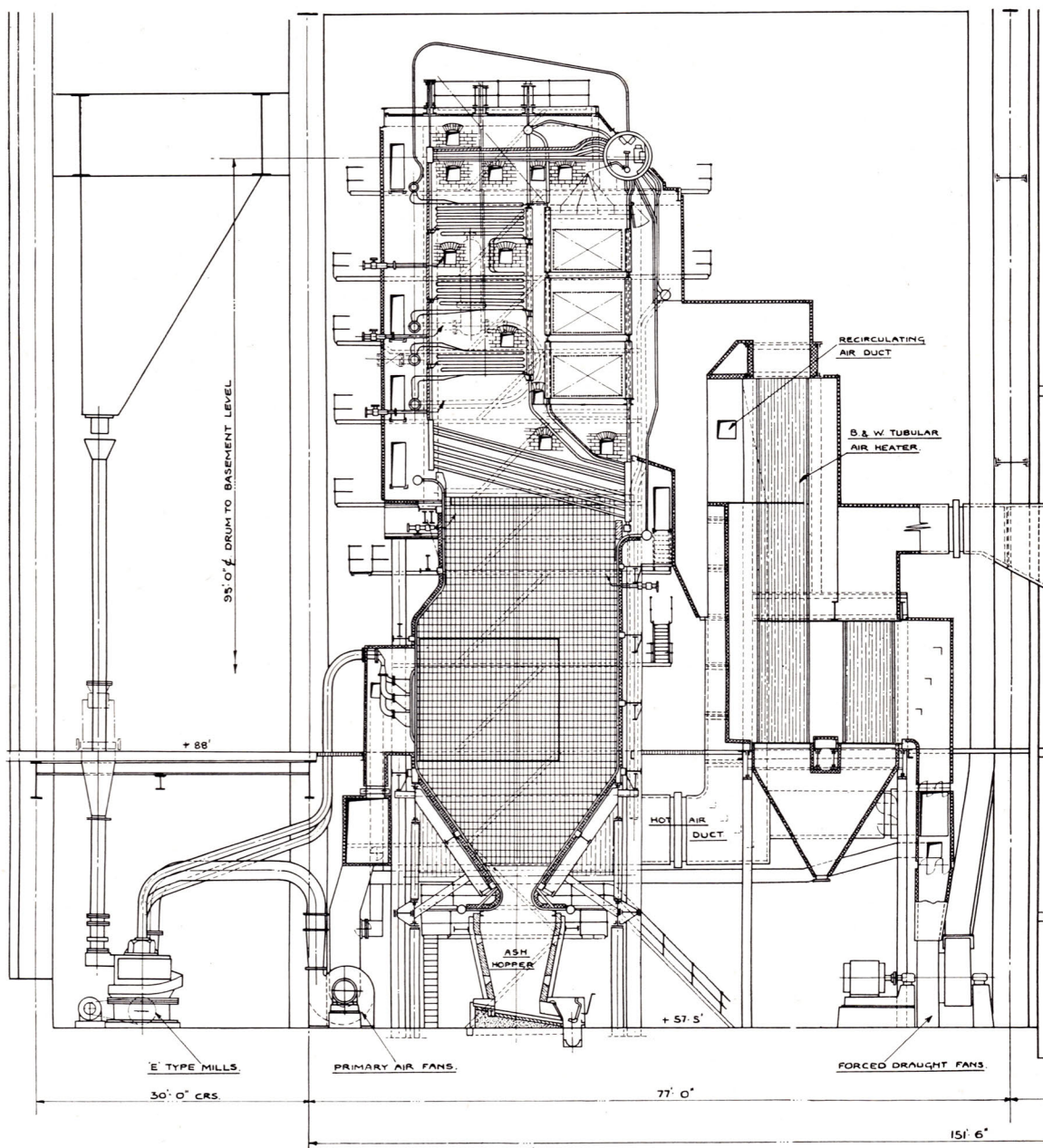
(17) Confirm that all draught and air pressure gauges and temperature indicators on the operating panel are connected to their correct points. Test indicating lights and alarms, and electrical interlocks.

(18) When the inspection is completed, leave open any access doors and casing panels necessary to enable the expansion movement of the boiler headers and water wall headers to be kept under observation during initial pressure raising.

(19) Timber and rubbish likely to obstruct the bunker coal valves or chutes should be removed from coal bunkers before filling, and coal valves should be operated. Oil fuel service tanks should be thoroughly cleaned before filling.

DRYING OUT FURNACE AND BOILER BRICKWORK

(1) Before a new boiler unit having refractory furnace walls and arches is put into service, the brickwork should be subjected to low temperature heating (by maintaining a slow fire for several days) to dry it out thoroughly, otherwise it is likely to spall and break up in service. The duration of the drying out period depends upon the thickness of the brickwork and the dryness of the bricks used,



Typical Pulverised Fuel Fired B. & W. Boiler Unit
M.C.R. 300,000 lb. of steam per hour, at 950 p.s.i. and 925°F

but should not be less than three days. Refractory bricks for building or repairing furnace walls and arches should always be stored under cover in a dry place.

(2) Boiler units with water-cooled furnace walls need no special drying out, as the brickwork of the boiler walls is subjected to sufficient low temperature heating during the boiling out process. Where solid fuel cannot be used for drying out, oil or pulverised fuel may be used, but only under the supervision of an engineer experienced in the operation of this equipment.

(3) Except on some pulverised fuel fired units where hot air is necessary to maintain flame stability when raising pressure, the air heater and/or economiser should be kept fully by-passed under all slow firing or light load conditions to avoid precipitation of acidulous moisture from low temperature flue gases.

(4) During the drying out period the boiler, economiser and airheater casings should be examined for flue gas leaks, after adjusting the air supply to create a slight pressure in the furnace and gas passes sufficient to cause smoke to emerge from any apertures remaining.

BOILING OUT PRESSURE PARTS

(1) When the furnace brickwork has been thoroughly dried out the pressure parts should be boiled out with a dilute solution of trisodium phosphate (Na_3PO_4), to remove grease and loose mill scale from the internal heating surfaces. If trisodium phosphate is not available, soda ash (Na_2CO_3) can be used.

(2) The quantities of these alternative chemicals to be added to the boiler water for boiling out are given below in pounds per thousand GALLONS of water.

Crystalline trisodium phosphate	$\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$	..	50 lb. <i>or</i>
Anhydrous trisodium phosphate	Na_3PO_4		22 lb. <i>or</i>
Soda Ash	Na_2CO_3		90 lb.

(3) With the boiler drum manhole open, see that there is about 6 in. depth of water in the bottom of the drum. Dissolve the chemical in hot water in a suitable tank, and transfer the solution into the drum by means of a portable hand pump or by other means, admitting it through the manhole whilst slowly feeding the drum with water. This procedure will ensure that the solution is thoroughly distributed in the drum. If the solution were poured into an empty boiler drum the whole quantity would disappear into the nearest boiler header or furnace wall downcomer.

(4) After closing the drum and adding water to bring the level into the gauge glasses, confirm that the height of water shown in the distant gauge glass is the same as that shown in the drum gauge glass.

(5) If the main steam range is ready to take steam and no other supply is available for heating it, open the superheater outlet valve and as many steam range valves as possible to flood the range with steam whilst the boiler unit is being

boiled out. This will help to free any mill scale in the pipes and dry the lagging. Steam traps on steam range drains should be by-passed and drain valves opened wide frequently to blow out sediment.

(6) Pressure should be raised to about 50 to 60 p.s.i. during the first day of boiling out. (See "Raising Pressure"). Close the air cocks when a strong flow of steam appears and make sure the pressure gauge pipe lines and water level gauges are clear by blowing them through as soon as sufficient pressure is available.

(7) Make a careful inspection of drum manhole joints and header handhole cap joints for leaks, and tighten up joints where necessary whilst the boiler pressure is below 20 p.s.i. Admit steam to new pipework wherever possible, and tighten up all non-metallic pipe joints. Inspect the whole unit for gas and steam leaks.

(8) Maintain low steam pressure during the first day whilst the unit is examined for leaks and the second coat of lagging is dried out. Normally the first coat of lagging on the drum should be allowed to dry before pressure is raised. Allow pressure to fall during the night, and raise it next day to 100 p.s.i., when fittings such as the external high and low water alarm, feed regulator, distant water level indicator, etc. can be pressure tested by steam, prepared for service, and afterwards shut off and drained. At this stage, the water connections need not be opened if it is considered undesirable.

(9) On the third day raise pressure to 200 p.s.i. to complete boiling out the pressure parts. (Boiler units without water walled furnaces may usually be boiled out satisfactorily in two days). The process of raising and lowering the pressure assists in removing mill scale from the internal surfaces. Operate dampers whilst the boiler unit is hot to make sure that they are free.

(10) Before raising pressure each day, open each boiler blowdown valve and furnace wall drain valve for a few seconds to get rid of any accumulated sludge, and add feed water to restore the water level to normal. On the last day, when boiling out is completed, open these valves for a longer period, but maintain the water level until the unit cools.

(11) When the pressure has fallen to about 20 p.s.i., blow down the boiler, economiser, and each furnace wall separately, open the air cocks and all the blowdown valves and feed a little water into the unit to wash out any remaining sludge. Then close the blowdown valves and refill the unit with clean warm water. When water shows in the gauge glasses, continue filling slowly until the drum and superheater are completely full and water flows from the air cocks. Then empty the unit again, commencing with the superheater.

(12) Remove sufficient handhole caps from the superheater headers, mud drum, furnace wall headers and economiser headers to make an internal inspection. Scrape out loose mill scale and sludge, and wash the headers through with a water jet from a hose. All blowdown and drain valves should be finally washed through and operated to make sure they are clear.

(13) Make an internal inspection of a representative number of boiler tubes in the lower rows. From their condition it will be possible to form an opinion

on the advisability of washing or brushing through all tubes in the lower rows and extending the inspection to the upper rows. Usually it is necessary to remove only the uptake header caps to inspect and wash through the boiler tubes. The downtake header caps do not need to be disturbed, but the mud drum should of course be opened.

(14) Open the steam drum for inspection and washing out ; (apply the protective coating where called for), fit the internal drum fittings such as the steam scrubber, internal feed pipe, chemical feed pipe, etc., and prepare the safety valves for setting as described under "Testing Safety Valves." The pressure parts can then be closed up and filled with condensate ready for raising pressure for floating the safety valves. A second boil out is rarely necessary, but should be undertaken if there is doubt about the cleanliness of the heating surfaces.

(15) The caps removed for inspection and cleaning purposes should be marked so that they can be observed, and if necessary tightened, whilst pressure is below 20 p.s.i., when pressure is being raised. The final retightening of cap joints should not be carried out until after the unit has been subjected to full steam pressure and the pressure is again reduced to 20 p.s.i.

(16) When raising the necessary pressure for boiling out, and also when raising full pressure for the first time, the boiler headers and furnace wall headers should be kept under observation to confirm that these parts are free to move as the unit expands. Particular attention should be given to the clearances under lower boiler headers and fire row boiler tubes, the mud drum and its blowdown pipes, the superheater boxes and drains, and to water-cooled furnace wall headers and drains, etc. The downward expansion movement of the mud drum and lower boiler tubes and headers of a large unit may be nearly 1 in., and the relative movement between the lower parts of a boiler and the upper parts of water-cooled furnace walls may exceed $1\frac{1}{2}$ in.

(17) The expansion may be calculated after referring to the drawing and noting the anchor points where the unit is bolted to the structure. Any discrepancy between the calculated expansion and the observed movement should be investigated, because restriction of free movement of the pressure parts may result in leakage and damage.

RAISING PRESSURE

(1) Before commencing to raise pressure in a unit make sure that all auxiliary equipment is in working order and test the controls. See that about 1 in. of water is showing in the gauge glasses and test the level by opening and closing the drain cocks. The cause of any sluggish movement of the water should be investigated.

(2) See that the keys of all blowdown and drain valves are removed. By-pass the air heater (except on pulverised fuel fired units requiring hot air for the mills). Open the air cocks. Open all superheater drains. Operate all dampers and set

them in the correct positions. Remove any combustible material in contact with superheater headers, steam pipes or ducts as it might later ignite spontaneously and cause trouble.

(3) Test main and auxiliary feed lines and make sure that the economiser is full by feeding some water into the unit through each line through the economiser to raise the water level about $\frac{1}{2}$ in. and afterwards close only the regulating valves so that water is readily available. See that the valve admitting feed direct to the drum is closed, and that the automatic feed valve is in the full open position and ready for setting.

(4) On a steaming economiser with a recirculating connection between the boiler drum and the economiser inlet header, see that the recirculating valve is open. This valve must always be open when pressure is being raised and also during banked conditions, except when feeding the unit with water.

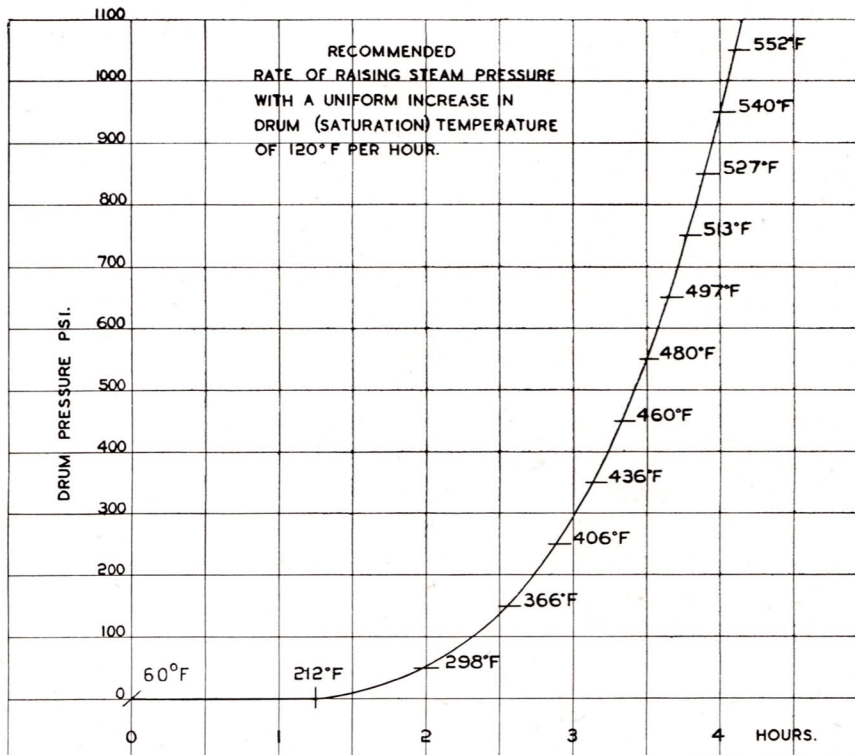
(5) See that all access doors on the unit are closed and that steam and water valves and pressure gauge cocks are workable and correctly set. Run the fans and prepare the firing equipment for service. See that blowdown pipes and steam drains are complete or otherwise safe to use.

(6) Before lighting up an oil fired or pulverised fuel fired unit open the dampers and pass air through the unit for a few minutes to clear the furnace and ducts of any gas; then adjust the dampers for lighting up with about 0.25 in. suction in the furnace.

(7) In high pressure boilers, pressure should be raised gradually to avoid large temperature differences and consequent abnormal strains in the boiler drums. This is of greater importance in the case of very high pressure boilers with thick drums. After lighting up, the rate of firing should be adjusted to produce an increase in the steam drum saturation temperature not greater than 120°F. per hour. With an initial boiler temperature of 60°F. steam should appear at the drum air cock not earlier than $1\frac{1}{4}$ hours after lighting up; pressure of 50 p.s.i. should be available after 2 hours, and 500 p.s.i. after $3\frac{1}{2}$ hours. This procedure should not be departed from except in an emergency. Boilers with refractory furnace walls and arches should be allowed a longer period for raising pressure to avoid spalling the brickwork by too rapid change of temperature.

(8) To avoid overheating the superheater tubes, the temperature of the gas entering the superheater zone during the pressure raising period should be limited to 930°F. (500°C), by adjusting the firing rate and admitting large quantities of secondary or tertiary air to the furnace. This temperature should be measured with a pyrometer on the first two or three occasions, until a safe procedure for raising pressure within the prescribed time and temperature limits is established.

(9) On stoker fired units there is usually no difficulty in limiting the gas temperature in the superheater zone to 930°F. during the pressure raising period, but on pulverised fuel fired units it may become necessary to shut off the pul-



verised fuel burners and then operate them intermittently to prevent the gas temperature exceeding the limit until the unit is delivering steam.

(10) The superheater outlet header drain must be kept open during the whole pressure raising period, to ensure a flow of steam through the superheater tubes to prevent overheating. The thermometer at the superheater outlet does not provide a reliable indication of the temperature of the steam in the superheater tubes whilst pressure is being raised. Superheater inlet and intermediate drains should be adjusted to drain away condensate, and opened wide periodically to guard against stoppage. They should be finally closed when the outlet drain is closed. Similar procedure should be adopted when putting a boiler into service from banked conditions.

(11) With non-drainable superheaters having a large number of loops in series it may be necessary to continue the starting up firing rate for half an hour or so after the boiler is up to line pressure and delivering steam, in order to evaporate water out of the superheater elements that have not been cleared, because there will be no flow through any tubes partially filled with water, and the portions of these tubes not in contact with water may otherwise be overheated.

(12) Close the air cocks when a strong flow of steam appears, and confirm that pressure gauge pipe lines and water gauges are clear by blowing them through when sufficient pressure is available. Thoroughly test each water gauge by

opening the drain cock and closing and opening the steam and water cocks alternately until satisfied that the connections are clear. On closing the drain cock the water should return promptly to the true level. The operating engineer should satisfy himself that each boiler operator fully understands how to test the water gauge.

(13) Before increasing the steam pressure above 20 p.s.i., confirm that all newly made handhole cap joints and manhole door joints have been fully tightened, and then keep all joints under observation during the pressure raising period.

(14) When raising pressure on a large boiler with water-cooled furnace walls the expansion of the water usually makes it necessary to blow some out to prevent the water level from rising above the gauge glasses. Should one furnace wall remain cool, indicating that its circulation has not begun, the opportunity should be taken to assist the circulation by drawing off water from the furnace wall drain valve instead of from the boiler blowdown valve. Furnace wall drain valves must not be opened however when the boiler unit is on load.

(15) It will be found advantageous to put the distant water level indicator into service while pressure is being raised, so that it will be ready for use, and boiler feeding can be controlled from the firing floor when the unit commences to deliver steam.

(16) Where an attemperator is included with the superheater, the attemperator regulating valve should be opened wide and the steam drain adjusted to drain away condensate. The attemperator blowdown valve should be opened for a few seconds to drain away any sludge from the vessel.

(17) To put the high and low water alarm into service the steam connection should be opened before the water connection to avoid possible damage to the float mechanism by a high velocity jet of water. The absence of water and the presence of steam in the vessel should cause the low water whistle to operate. If that is satisfactory, open the water connection and close the steam valve until the water in the vessel rises and operates the high water whistle. If that also is satisfactory, re-open the steam valve and allow the alarm vessel to settle to its normal temperature.

(18) The alarm should be checked by raising and lowering the water level in the boiler as soon as the unit commences taking feed water. When the alarm is correctly set it should give audible warning if the water level rises or falls to within $1\frac{1}{2}$ in. of the top or bottom of the gauge glass. The alarm may operate at an incorrect water level if the vessel is unlagged or the boiler pressure is low.

(19) When raising pressure on the first occasion the expansion of the boiler and furnace should be kept under observation as already described.

(20) After a new unit has been brought up to working pressure and temperature, it is important to take up on all gasketed joints. A good practice, in order to avoid danger to personnel, is to allow the pressure to drop to 20 p.s.i., before proceeding with this work, which should be carefully carried out as described. See "Inspection."

TESTING SAFETY VALVES

(1) After the pressure parts of a new unit have been boiled out and it is otherwise ready for steaming, the safety valves should be "floated" with the superheater stop valve closed before the unit is put into service, to make sure that the valves lift and close satisfactorily at the specified pressures. (The Boiler Insurance Companies usually require a representative to be present during this test).

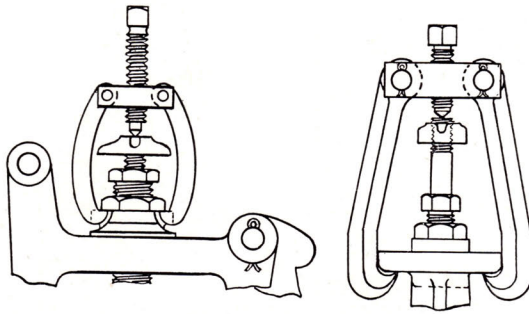
A full load accumulation test over a period of several minutes is not practicable on account of the danger of overheating the superheater tubes while steam is being discharged through the drum safety valves.

(2) During the inspection of the boiler after boiling out, the safety valves should be lifted by hand to confirm that they are free. The escape pipes should be inspected to confirm that they are led to safe points of discharge and are properly secured, and that the safety valve drains are clear. Where boiler regulations do not allow compression rings of spring loaded safety valves to be fitted in halves, the rings should be removed temporarily, the adjusting screws set to the original marks ready for floating the valves when pressure is raised, and the guards and locks replaced.

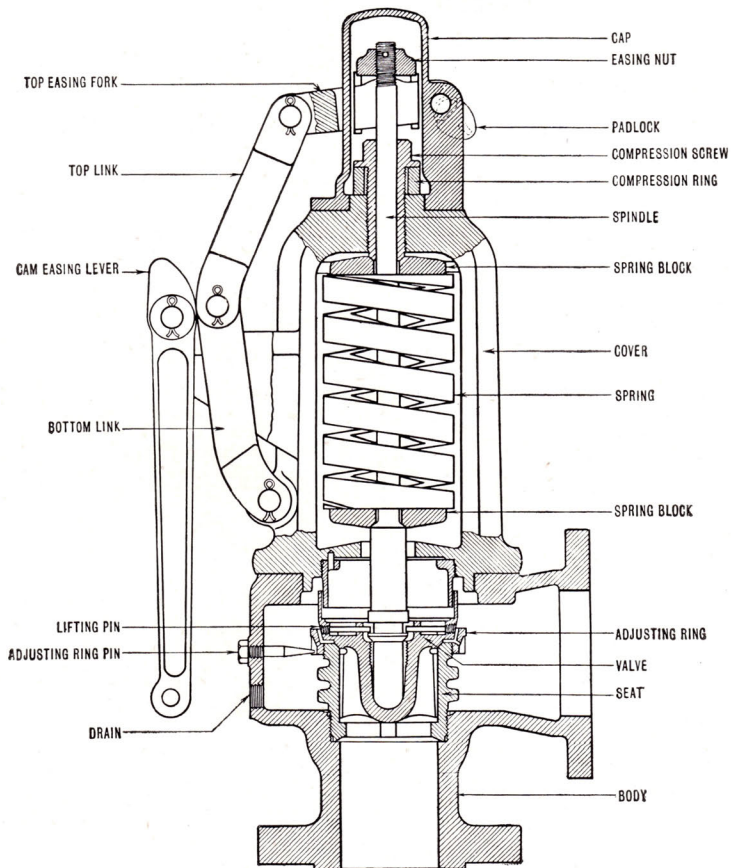
(3) The superheater safety valve is set to lift at a pressure lower than the lowest drum safety valve by an amount slightly greater than the pressure drop through the superheater at full boiler load. This ensures that the superheater safety valve lifts first to maintain a flow of steam through the superheater under all load conditions if the steam demand is less than the quantity generated. However, in designing some highly rated boiler units where the superheater pressure drop is comparatively large, it is sometimes arranged for the lowest drum safety valve to lift first at high boiler loads. In these cases the drum safety valve lifts first only when there is a large volume of steam passing through the superheater and there is little risk of the superheater being overheated. It should be noted, however, that excessive steam temperature may be reached unless the rate of firing is quickly reduced.

(4) Commencing with the valve set to lift at the highest pressure, each valve should be floated separately by raising the steam pressure whilst the other valves are temporarily "gagged," i.e., held down on their seats. When the pressure approaches the lifting pressure, increase the rate of firing to lift the valve sharply, and as soon as the valve is fully lifted reduce the firing and air supply, and add feed water to restore the water level. By commencing with the valve having the highest setting, and working downwards, it is usually unnecessary to replace the gags on valves that have been floated, unless the setting pressures are very close together. Care should be taken to see that the lower setting valves do shut off at their designed pressures, in order to prevent continuous leakage from these valves. Refer to the valve makers' instructions.

(5) Spring-loaded valves should be "gagged" by means of the gags supplied with the valves, taking care not to damage the valve seats or bend the valve



Typical testing gags.



Section of a Typical Dewrance-Consolidated High Lift Safety Valve.

spindles by screwing the valves down too hard. Weighted lever valves should be "gagged" by adding extra weight temporarily. If any adjustment is necessary to the setting of a spring-loaded valve, the compression ring should be modified to suit and replaced. The valves should be finally inspected by the responsible engineer, the guards replaced and the keys put in a safe place.

(6) When floating the safety valves the water level should be kept below half glass, feed water should be available at the regulating valve, and the superheater outlet drains should be open.

BLOWING THROUGH STEAM MAINS

(1) Before commencing to operate a new boiler unit it may be considered advisable in some circumstances to take the precaution of scouring the steam pipes by blowing steam through to atmosphere. This involves some extra work in making and fitting temporary pipes.

(2) Where this procedure is adopted, the pipe from the boiler to the steam receiver may be dealt with by removing one of the receiver outlet valves and fitting a temporary pipe in its place to carry the steam outside the building. Care should be taken to brace the pipe adequately to resist reaction from the discharged steam. Open the receiver drain valve and see that all other receiver valves are closed, then open the boiler stop valve carefully and pass a strong blast of steam through the receiver.

CONNECTING THE UNIT TO THE RANGE

(1) To connect a boiler unit under pressure to a cold steam range, the range should first be warmed up and charged with steam at a pressure equal to the boiler pressure by slowly opening the superheater outlet by-pass and allowing the steam range to heat up gradually. The range drains must be opened to allow condensate to be expelled, and any steam traps on these drains should be temporarily by-passed until the boiler is steaming. On a new plant the steam traps should be by-passed for a longer period to avoid their choking with mill scale.

(2) The superheater outlet header drain should of course be open to ensure a flow of steam through the superheater whilst pressure is being raised. The boiler water level should be below half-glass when the stop valve is opened, so that priming will be avoided if there is a sudden flow of steam caused by a premature steam demand.

(3) Before the superheater outlet valve is opened the non-return valve (if fitted) should be lifted off its seat by the hand lever to ensure that it is free to lift. When the range pressure equals the boiler pressure, thoroughly drain the steam pipe and superheater, and slowly open the superheater outlet valve wide. Adjust the rate of firing to maintain pressure without lifting the safety valves. Keep the superheater drains open until the unit commences taking feed, or until the flow meter indicates that the unit is on steady load.

(4) Test the gauge glasses by blowing them through, and confirm that the distant water level indicator agrees with the boiler gauge glass. (This should be verified at each change of shift).

(5) A reliable assistant should be stationed at the feed regulating valve, to be solely responsible for feeding water into the unit and maintaining the water level until the high and low water alarm is tested and the automatic feed regulator is in service, when responsibility for feeding the unit can be taken over by the boiler operator. This precaution is particularly necessary in starting up a new boiler unit, as the operators may be unacquainted with the plant and various other duties claim their attention at this time.

(6) Commence feeding a steady flow of water to the unit immediately the water level begins to fall. Avoid intermittent feeding, which may cause undesirable temperature changes in the economiser. Close the superheater drains.

(7) When the hand feed regulating valve is adjusted to give a steady feed, the economiser recirculating valve (where fitted) on a steaming economiser must be closed. This should be established as a routine. Similarly, when the feed regulating valve is closed after shutting down the unit, the recirculating valve must be opened.

(8) Test the high and low water alarm by raising and lowering the boiler water level, and record the levels at which the alarm operates. Blow through the feed regulator thermostat and allow it to cool for half an hour before putting the regulator into service.

(9) It is advisable to steam a new unit on light load for a day or two to prove its reliability and allow the operators to become familiar with the controls. Full use should be made of this period to get the instruments working satisfactorily and to try out all plant and equipment belonging to the unit. Desuperheater or atomizer plant should be adjusted so far as the reduced load permits.

(10) Except on pulverised fuel fired units requiring hot air for the pulverising mills, the air heater should be by-passed under all light load and banked conditions to avoid precipitation of acidulous moisture from the flue gases on to the heating surface as this causes rapid fouling and corrosion. Fortunately, airheaters on pulverised fuel fired units are not usually affected by these troubles.

(11) The airheater should not be put into service until the combined temperatures of the inlet air and the outlet gas total at least 300°F., and should be partially by-passed when necessary to maintain the combined temperatures above this figure. Where a recirculating duct is fitted, hot air should be recirculated to the forced draught fan inlet to maintain the temperature of the inlet air above 110°F., and thus allow the heater to be retained in service at lower boiler loads. Care should be taken to avoid overloading the forced draught fan by recirculating too much air.

(12) Where an airheater is not included, the economiser usually has a gas by-pass. In this case, when starting up with cold feed water, the boiler should be fed in the normal way through the economiser, but the gases should be completely by-passed while the feed water temperature remains below 140°F.

SUGGESTED VALUES

FOR

FEED AND BOILER WATER

FEED WATER

BOILER PRESSURES	LOW PRESSURE	MEDIUM PRESSURE	HIGH PRESSURE
lb./sq. in.	up to 250	250-500	500 and above
<i>Hardness in parts per million expressed as CaCO₃</i>	Preferably not more than 10 parts.	5-10 parts max.	Zero.
<i>Alkalinity</i>	pH not less than 8·5 with un-deaerated feed water.	pH 7·5-8·5 with mechanical deaerated feed water.	pH 7·5 with complete deaeration, mechanical plus chemical.
<i>Sodium Sulphate</i>	Sufficient to give a Na ₂ SO ₄ /NaOH ratio of not less than 2·5 in boiler water except where drums are forged or welded and stress relieved.		
<i>Oxygen Content ml. per litre</i>	No recommendation. Rely on alkalinity and feed troughs, etc.	0·05 lower end of pressure range 0·02 higher end of pressure range	Zero mechanical plus chemical deaeration.

BOILER WATER

<i>Hardness</i>	Zero.	Zero.	Zero.
<i>Total Alkalinity</i>	Not less than 15% to 20% of the total dissolved solids.	As arising from the feed water and addition of phosphate for conditioning. pH should be greater than 8.5.	
<i>Sodium Sulphate</i> <i>Caustic Soda</i>	Ratio not below 2.5 in boilers with riveted drums or welded drums which have not been stress relieved.		
<i>Sodium Sulphite</i> <i>(parts per million)</i>	—	—	50 to 100
<i>Phosphate (parts per million)</i>	50-100 parts expressed as PO ₄ .		
<i>Total Solids</i> <i>(parts per million)</i>	7000 (max.) at higher end of pressure range.	5000 at lower end of pressure range. 2000 at higher end of pressure range.	1500 at lower end of pressure range. 1000 at higher end of pressure range.

(13) Where the economiser has no gas by-pass and the temporary use of cold feed water is unavoidable, steps should be taken to raise the feed temperature to at least 140°F. by improvised steam heating or some other means, to avoid excessive precipitation of acidulous moisture on the external surface of the economiser tubes.

NORMAL STEAMING

(1) Chemical treatment of the feedwater, conditioning of the boiler water and regulation of the boiler water concentration by blowing down should be placed upon a routine basis as soon as possible after a new boiler unit goes into service. Until this is done the boiler blowdown valves should be opened at least once every eight hours for a sufficient length of time to lower the water level by two inches. Scale-forming matter in the boiler water must be kept at an absolute minimum, and oil must be excluded.

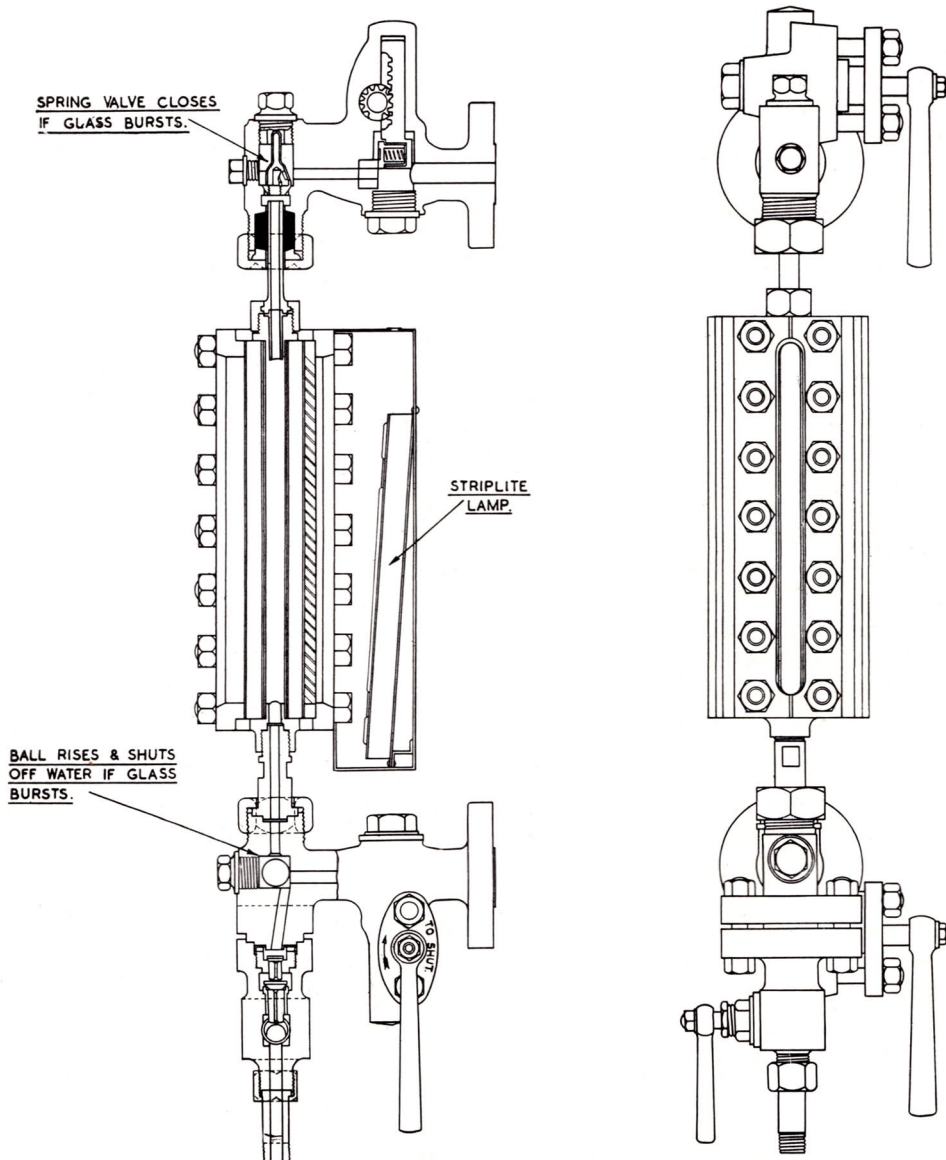
(2) Analyses of the boiler water should be made at least once a week and co-ordinated with daily hydrometer tests to provide a clear picture and record of the boiler water conditions upon which to base the chemical treatment. Refer to our booklets, "Water Treatment" and "Boiler Water Concentration Control." It should be kept in mind that unsatisfactory boiler water conditions may in a few months result in serious troubles, such as joint leakage, priming, corrosion, tube blistering and loss of efficiency. A deposit of scale $\frac{1}{2}$ m.m. thick, or a film of oil $\frac{1}{32}$ m.m. thick may cause blistering and rupture of highly rated furnace tubes.

(3) The boiler water concentration should be maintained below the permissible maximum by blowing down at regular intervals, or by regulating the continuous blowdown valve (where one is fitted). In addition, the boiler blowdown valves should be slowly opened wide for a few seconds each day to remove any sludge from the mud drum. Where an attemperator is included in the unit the attemperator blowdown valve should be opened at regular intervals to avoid excessive concentration in the attemperator. Blowdown valves should be opened very slowly to avoid shock in the pipelines.

(4) It may be advisable to bank water-cooled furnace units for a minute or two each week during the first few weeks to enable the water wall drain valves to be opened for a few seconds. These valves must not be opened whilst the unit is on load because of the risk of interfering with circulation in adjacent wall tubes. (These occasions are convenient for testing the high and low water alarm). Only one blowdown valve or drain valve should be opened at a time, and whilst a valve is open the operator should undertake no other duty than to observe the water level or receive signals from another person observing the water level.

(5) A tentative sootblowing routine should be established as early as possible. All blowers should be operated once per shift until experience indicates if any alteration is necessary. Certain blowers, such as furnace blowers, may need to be operated more frequently than this and others less frequently. The sootblower operating pressures should be measured to make sure that they agree with the pressures recommended on the drawings, and if they do not agree it may

WATER GAUGE FITTING



TO TEST THE WATER GAUGE :—

1. Crack the drain valve open for half a minute or so to allow the glass and fitting to reach maximum temperature gradually without thermal shock, then open the drain valve wide. Opening the drain valve wide suddenly may cause the glass to fracture.
2. Test the steam connection by closing the water valve and allowing steam to escape through the gauge glass to the drain until satisfied that the steam connection is clear.
3. Open the water valve.
4. Test the water connection by closing the steam valve and allowing water to escape to the drain until satisfied that the water connection is clear.
5. Open the steam valve.
6. Close the drain valve, when the water should return promptly to its true level in the gauge glass. Any sluggishness in the movement of the water would indicate that the steam connection or the water connection is partially choked and the water level may be false.

be necessary to modify the orifice plates in the sootblower pipe lines. Refer to the Sootblower Instructions.

(6) High and low water alarms should be tested at least once a week by raising and lowering the boiler water level.

(7) Gauge glasses should be blown through and tested by the responsible operator of each shift at the time of taking over. He should satisfy himself that the steam and water passages are clear, that the gauge glasses are adequately illuminated and easily visible, and that the distant water level indicator agrees with the drum gauge glass. Leakage from a drain cock or joint on the water column may cause a false level in the gauge glass.

(8) The distant water level indicator should only be blown through as stated in the makers' instructions. Where it is connected to the drum gauge glass mounting it must be isolated whilst the drum gauge glass is tested, or the indicator liquid may be displaced.

(9) In the event of loss of water in the gauge glasses due to failure of the feed supply, the fans should be immediately tripped and the fire extinguished or run off, unless a decision to keep the unit in service is made by a responsible engineer who is fully aware of the feed situation and knows that the supply will be restored in a few seconds. In a distinct case of low water where the water has, or may have been out of the gauge glasses long enough for the boiler to become empty, the primary objective should be to extinguish the fire, as the re-admission of feed water may result in further damage to the boiler.

(10) When the unit commences full load steaming the operating engineer should check the performance and establish standard operating conditions that can be used as a guide to safe and economical everyday operation. The temperatures and draughts should be accurately measured over a period of several hours to ascertain whether they are reasonably in accordance with the anticipated figures. Minor discrepancies are of little consequence provided that the final gas temperature, upon which the efficiency of the unit depends, does not materially exceed the anticipated figure. If the final gas temperature or the draught loss through the unit is found to be materially higher than anticipated, the cause should be sought and corrected.

(11) An Orsat apparatus should be used to check the CO₂ content of the flue gases at the boiler outlet, economiser outlet and induced draught fan. A drop of more than 2% between the boiler outlet and the induced draught fan indicates excessive infiltration of air into the economiser or airheater, and steps should be taken to stop it, but great care is sometimes necessary to avoid false CO₂ readings from the boiler outlet and the economiser outlet caused by stratification of the flue gases.

(12) After two or three weeks' steaming the unit should be shut down and completely emptied and all lower boxes cleaned and inspected. The lower horizontal parts of furnace wall and hopper tubes, especially wing tubes, should be inspected for accumulations of mill scale at the bends. During subsequent

service the water wall drain valves should be operated whenever a suitable opportunity occurs.

(13) If the draught loss through the unit increases noticeably whilst the unit is in service an inspection of the external heating surfaces should be made at the first opportunity, to locate and remove any deposits from the gas passages. The airheater should receive particular attention in this respect to ensure satisfactory clearance of any choked parts, otherwise corrosion and perforation of the heater elements may soon result.

(14) It is advisable to commence records of fuel consumption, evaporation, flue gas analysis, gas temperatures, draughts, fuel analyses, etc. as early as possible, as they provide information that is useful to detect and rectify faulty operating conditions if trouble occurs later.

SHUTTING DOWN AND BANKING

(1) When the load on a boiler unit is being reduced to take the unit out of service, the airheater should be fully by-passed. Where the plant design excludes an airheater but includes an economiser fitted with a by-pass, the economiser should be fully by-passed on the gas side. The secondary air fan can be stopped, the feed regulator should be taken out of service, and the feed supply regulated by hand before the unit ceases steaming.

(2) On a pulverised fuel fired unit the milling and feeding plant should be shut off at the appropriate moment to drop load, but the air supply must not be shut off until the burners and pipes are quite clear of fuel.

(3) On a stoker-fired unit the coal should be cut off at the stoker hopper, the grate speed reduced to burn the fire off short, and the forced draught fan then stopped. When the firebed is clear of the firedoor, stop the grate and the induced draught fan, and reduce the chimney draught to a minimum. Open the stoker front ashpit doors and the side doors.

(4) Close the superheater outlet stop valve a minute or two after the unit ceases to take feed, but leave its by-pass open until the pressure falls. Open the superheater drains to prevent condensate accumulating and to keep a flow of steam passing until the superheater has cooled. Open the economiser recirculating valve on a steaming economiser, after closing the feed regulating valve.

(5) If the unit is required to be cooled quickly, it should not be cooled by allowing large quantities of cold air to pass into the furnace, because the sudden temperature change may damage the brickwork. The unit should stand for at least two hours with fans stopped and dampers slightly open before the induced draught fan is again started for cooling purposes.

(6) If the unit is to be emptied, the blowdown valves should not be opened until the pressure has fallen to below 30 p.s.i. The air cocks should be opened before pressure disappears, because if a vacuum forms in the pressure parts any

cap joints not fully tightened may become loosened and would leak the next time pressure is raised.

(7) The procedure for banking a unit to keep it available at short notice is similar to the procedure for shutting down. An oil fired or pulverised fuel fired unit needs to be flashed up at intervals to maintain the pressure. A stoker fired unit requires a bank of slowly burning fuel to be kept alight on the grate just clear of the furnace side of the firedoor to maintain pressure and facilitate re-starting. Sufficient air should be allowed to pass through the furnace and gas passes of a banked unit to prevent any accumulation of combustible gases which might form an explosive mixture, and the water level should not be allowed to fall out of sight.

PERIODICAL INSPECTION AND CLEANING.

(1) A new boiler unit should be inspected externally at least twice during the first year, if possible, and an examination of the internal surfaces is useful to give confirmation of satisfactory water conditions, etc. By observing the position and nature of any external deposits, faulty operating conditions may be revealed and appropriate steps can be taken. When men are to enter a unit on these occasions, care should be taken to free it of gas by running the fans and passing air through the furnace and gas passes, and also to guard against burns from accumulations of hot flue dust or injuries from falling slag in the furnace. Only the minimum amount of cleaning of refractory faced surfaces compatible with safety should be carried out, as the clearing of slag inevitably tears away some of the surface of the refractory.

(2) In the United Kingdom a general survey of boiler pressure parts and an overhaul of fittings is necessary every fourteen months to comply with the regulations of the Factories Act. On these occasions the operating engineer should make a thorough inspection both before and after any hand cleaning or maintenance work is carried out, looking particularly for evidence of internal or external corrosion, leakage, overheating or structural deterioration. Records of these inspections, and any necessary repairs, should be kept in a uniform manner.

(3) When preparing to inspect a boiler internally make certain that no vacuum exists in the drum before releasing and opening the manhole door. The drum should be well ventilated before anyone is allowed to enter, and the valves connecting the unit with steam, feed or blow down lines under pressure or liable to be under pressure from other sources should be locked in the closed positions. It is recommended that there should be two closed valves on each pipe connecting the unit opened for inspection to any source (or possible source) of steam or water pressure.

(4) Any "pitting" or other corrosion found should be scraped and cleaned with a wire brush until the metal is perfectly clean, then coated with dry blacklead and polished by brushing. Any boiler tube joints showing signs of having leaked

should be carefully re-expanded, but the attention of Babcock & Wilcox Ltd. should be drawn to any repetition of the trouble. Superheater tube joints should only be re-expanded if they are known to leak under full steam pressure, as slight "weeping" from these joints under low steam pressure or during a hydraulic test usually takes up and is not of great significance. Seal-welding the ends of superheater tubes is now a normal means of repairing troublesome expanded joints, but here again, the attention of Babcock & Wilcox Ltd. should be drawn to the circumstances before finally deciding upon this means of repair.

(5) The most satisfactory method of removing bonded deposit from the gas side of economisers and airheaters is now recognised to be water washing. Where the design of a plant does not permit washing water to be led away, it is worth while fitting temporary baffles and ducting so that this method of cleaning can be adopted. It may be necessary to wet the deposit first with an alkaline solution to neutralise any acid, and the heating surfaces should then be thoroughly washed with a hose. It is essential to dry off quickly afterwards to avoid corrosion, and this can best be achieved by commencing the cleaning operation as soon as possible after the unit is shut down.

PRESERVATION OF IDLE BOILERS

(1) A boiler unit not required in service for a period long enough to involve the risk of internal or external corrosion should be adequately prepared for laying off to preserve it against corrosion. Where the unit is to be out of service for several months and is not likely to be required at short notice, the "dry method" of preservation is preferable. Where the unit will be out of service for only a few weeks and is likely to be required to steam at any time, the "wet method" is more practicable, as the unit can be quickly made ready for lighting up by running out some of the water to bring the water level into the gauge glasses.

(2) Whichever method is used, the achievement of the desired result depends largely upon thorough removal of all internal sludge and external deposit likely to set up corrosion. Ash or soot must not be permitted to remain in the collecting hoppers or in contact with metal anywhere in the unit.

(3) The following recommendations represent present-day practice, but may be modified to suit local conditions or experience gained with individual plants.

Dry Method.

(4) Where dry preservation is to be adopted, special care is necessary to remove any water remaining in pockets or superheater tube loops when the unit has been cleaned internally. A jet of compressed air may be convenient for this purpose. Afterwards, the unit can be dried out by coke braziers and/or a circulation of warm dry air from a portable blower directed into the headers and tubes.

(5) When the internal parts are perfectly dry, trays containing unslaked lime to the extent of 20 lb. per 1,000 sq. ft. of heating surface should be placed in the headers and drum to absorb the moisture held in suspension in the air trapped in the unit. After replacing manhole doors and handhole caps, all valves and cocks must be shut and care should be taken to prevent water, steam or air leaking into the unit.

(6) When external cleaning is completed, trays containing unslaked lime may be placed in the furnace and gas passes if there is any dampness present. Doors opening into the setting and ducts should be shut, and all dampers tightly closed. Inspections should be made at intervals of three months and the lime containers replenished as necessary. Do not fail to remove all internal and external lime containers before filling the unit with water and lighting up.

Wet Method.

(7) Where the wet method is to be adopted, the unit should be cleaned internally and externally and then filled with feed water to working level through the economiser. The chemicals necessary to give the water the required alkalinity should be introduced continuously with the feed water to avoid variations of concentration which might otherwise occur.

(8) The water fed into the unit should have a caustic alkalinity of up to 850 parts per million in the case of low pressure boilers below 300 p.s.i., but not more than 150 parts per million in the case of high pressure boilers above 500 p.s.i. which may be required to steam at a few minutes notice without being emptied and refilled. Sodium sulphite should be added in all cases to give a concentration of 30 parts per million, to absorb any oxygen remaining in the water when preparations are completed.

(9) The boiler unit should be steamed on light load for a few hours to stabilise the water conditions and remove oxygen, and shut down with a high water level. Just before the pressure disappears, deaerated feed water should be added until the drum and superheater are completely filled so that water flows from all air cocks. The air cocks should then be shut and the pressure in the unit increased to about 15 p.s.i. which should be maintained by static pressure from an overhead tank or by pumping up as necessary.

(10) When all preparations are complete, trays containing unslaked lime should be placed in the furnace and gas passes before closing up, to guard against sweating. The unit should be finally inspected and all doors and dampers closed. During cold weather, the use of coke braziers may be necessary to guard against the effects of frost. On suitable warm dry days air from the boiler house may be drawn through the setting by running the I.D. fan and admitting air to the furnace.

(11) The idle period might be extended if arrangements can be made to circulate the water in the unit and representative samples are obtained to check the alkalinity and sulphite content. This involves the use of a small circulating pump connected up to draw water from all blowdown and drain valves and discharge it back to the economiser inlet. Otherwise the idle period should be limited to about a month when the unit should be steamed again on light load to circulate the water and allow samples to be taken so that any necessary chemical adjustments can be made.

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